ENTELODONTS FROM THE BIG BADLANDS OF SOUTH DAKOTA IN THE GEOLOGICAL MUSEUM OF PRINCETON UNIVERSITY.

Investigation aided by a Grant from the Marsh Fund of the National Academy of Sciences.

By WILLIAM J. SINCLAIR.

(*Read April 22, 1921.*)

I had always assumed that entelodonts were rare fossils in the White River Oligocene until last summer when the Princeton Expedition to South Dakota, within an area of about two square miles in the valley of Indian Creek, in Pennington County, between July 14 and 27, collected five skulls and two lower jaws belonging to three species of *Archæotherium* and noted, but refrained from collecting, perhaps as many more fragmentary specimens within the same area. This mass of new material made it desirable to restudy the Princeton entelodont collection as a whole, as much of it had never been adequately determined. Fortunately, the timely appearance of Mr. Troxell's[1] excellent paper on the entelodonts in the Marsh collection at Yale greatly facilitated these studies. Whether certain of the characters used in the classification of these animals are of specific importance or of the nature of secondary sexual structures can not yet be determined. For the present it is safer to give a separate specific name to each well-defined variant, based on adequate material, than to group together forms which may have been rapidly mutating and thereby developing differences of the first degree of importance for detailed faunal and stratigraphic studies. A review of the genera and species represented follows.

[1] *Am. Jour. Sci.*, Vol. L., Nov.–Dec., 1920, pp. 243–255, 361–386, 431–445.

I. From the Titanotherium Beds.

Archæotherium scotti sp. nov.

In 1895 Professor Scott[2] announced the discovery of the classic specimen now known as No. 10885 and mounted in the Geological Museum of Princeton University. This almost complete and unique skeleton (not "two almost complete skeletons" as mistakenly stated in the preliminary report) was found in the summer of 1894 by Mr. H. F. Wells in the upper Titanotherium beds in Corral Draw, South Dakota (whether in Pennington or Washington Counties does not appear), was secured by Mr. J. B. Hatcher and excavated by him May 11, 1894, and was referred by Professor Scott, in his announcement to the International Zoölogical Congress at Leyden, to Leidy's

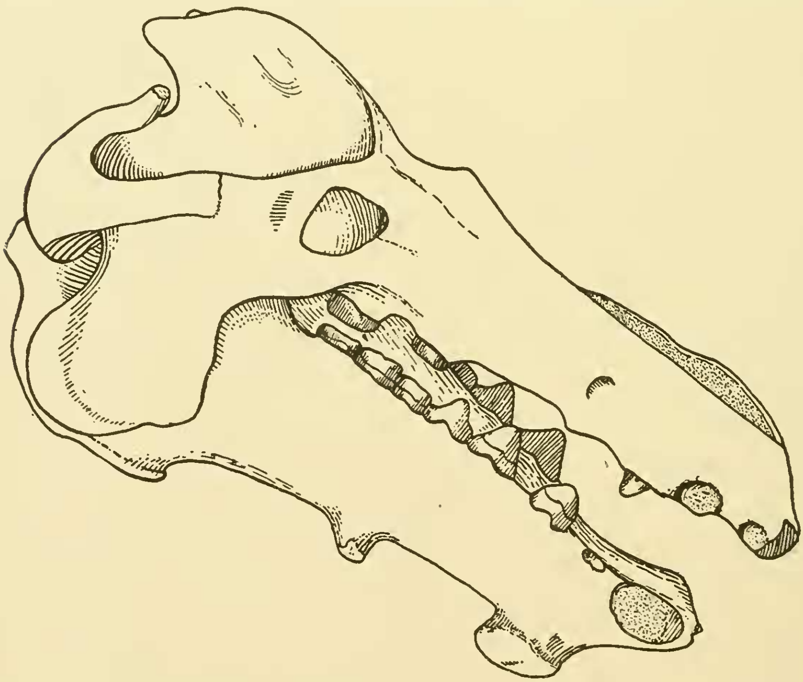

Fig. 1. *Archæotherium scotti* sp. nov. Holotype, No. 10885. Three-quarter view of the skull and jaws from the left side, in the position in which it stands on the mounted skeleton, approximately one-sixth natural size. Drawn from photograph and the specimen.

[2] W. B. Scott, "Compte-Rendu des Séances du Troisième Congrès International de Zoologie," Leyde, 16–21 Septembre, 1895. Leyde, E. J. Brill, 1896.

Elotherium ingens, "without paying much attention to the species," as he has since told me.

Elotherium ingens, as originally constituted,[3] is a composite, comprising "fragments found in association with the fossils of *Elotherium mortoni* in the Mauvaises Terres, which appear too large to belong to this species, even making allowance for a considerable range in size." These were from the collection of Dr. Hayden, did not pertain to a single individual and were from unknown horizons. The first to be mentioned by Dr. Leidy[3] is the "fore part of the lower jaw, in advance of the second premolars," which therefore becomes the type specimen of *Elotherium* (=*Archæotherium*) *ingens.* In the light of what is at present known regarding the larger entelodont species of the White River Oligocene, the various fragments included by Leidy with the type of *ingens* are specifically indeterminate, since the latter retains no teeth.

A suggestion of Mr. Troxell's, in a personal letter, first called my attention to the possibility that our Princeton specimen represented a new type and, on reviewing the subject, I agree with him that the mandibular fragment figured by Leidy in front view on Plate XXVII., Fig. 10, of the "Extinct Mammalian Fauna," copied here on a smaller scale as Fig. 4, differs both in size and structure from the corresponding part of the specimen monographed in detail by Professor Scott,[4] for which I now propose the new name *Archæotherium scotti* (Figs. 1, 2, 3, 22), characterizing it as follows:

1. Very long and thick dependent malar process directed downward, forward and outward (the latter curvature probably intensified by crushing), with thin sinuous anterior margin and greatly thickened, round-edged, club-like posterior distal end, projecting so far below the anterior distal end of the process that the latter seems to contract in breadth a second time after a minimum of 88 mm. and a maximum of 114 mm. The greatest thickness of the enlarged end is 46 mm. The outer face of the process is convex transversely at the narrowest part, convex behind and flat in front at the widest

[3] J. Leidy, "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.,* Vol. VII., Second Series, p. 192, 1869.

[4] "The Osteology of Elotherium," *Trans. Am. Phil. Soc.,* Vol. XIX., pp. 273–324. Pls. XVII., XVIII., 1898.

expansion and concave longitudinally, accentuated by crushing. Its front margin, at the point of greatest expansion, is in line with the posterior border of the orbit.

FIG. 2.

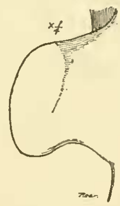

FIG. 3.

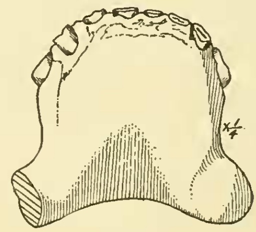

FIG. 4.

FIG. 2. *Archæotherium scotti* sp. nov. Holotype, No. 10885. Anterior mental process of the right side, seen from directly in front, one quarter the natural size.

FIG. 3. *Archæotherium scotti* sp. nov. Holotype, No. 10885. Right anterior mental process from below, one quarter the natural size. To get the proper orientation, the drawing should be held overhead in an inverted position and viewed from below.

FIG. 4. *Archæotherium ingens* Leidy. Holotype. The front of the lower jaw showing the dependent processes. Copied from Leidy's figure, one quarter the natural size.

2. The zygomatic arch is 46 mm. wide at its narrowest part and the jugal process is very thin, and, while it extends to the front edge of the glenoid fossa, it takes no part therein and is not visible in side view, but only from below, as shown by the deep shading in Fig. 1.

3. $P\bar{1}$ seems to have been double-rooted, judging from extremely slight indications of a median constriction across the alveolus, but it would be equally permissible to assume that the roots were conjoined, with merely a groove extending lengthwise between them. The empty alveolus measures 28 x 19 mm.

4. The anterior mental processes are very large and extremely broad at the base, anteroposteriorly (Fig. 3), but vertically the neck is only 20 mm. thick at the middle, thinning out to an edge front and rear. Distally, the process swells out to an oval bulb 61 x 36 mm. in diameters and curves outward, backward and upward (in part due to crushing). So far as can be determined from the figure of *A. ingens* (Fig. 4), the corresponding structure seems to have

been of uniform dimensions throughout, with a hemispherical termination. Some interesting differences in proportions appear in the following measurements given by Leidy,[4a] to which have been added the appropriate figures for the species described herein:

	A. ingens, type.	*A. wanlessi*, type.	*A. scotti*, type.
Height of symphysis (4 inches)	101.5 mm.	125 mm.	173 mm.
Breadth of jaw outside of canine alveoli (3¾ inches)	95.5	100	110.5
Breadth between ends of mental protuberances (4¾ inches)	121	92.5	157 +
Depth of jaw below first premolar (2¾ inches)	70	73	81

The posterior processes are long affairs with constricted neck and trilobate head, projecting outward and forward, the slope in the former direction being intensified by crushing.

To facilitate rapid comparison, the principal measurements are included in the table on page 114, appended to the description of *A. wanlessi*.

The drawing (Fig. 1), which has been traced from a photograph and corrected from the original specimen, differs in many important respects from Von Iterson's plate in Professor Scott's memoir,[5] especially in the delineation of the cheek flanges, the sagittal crest, the mental processes, and in the omission of teeth not present in the original, all of which greatly alter the contour of the skull as hitherto figured. As no drawings of the teeth have been published, the following notes are added to aid in making comparisons:

Upper incisors and canines had dropped out previous to fossilization. P1 is a small double-rooted tooth placed obliquely to the general direction of the tooth row and 11 mm. (left) to 18 mm. (right) back of the canine. It is well back of the canine on the right side, but has its anterior edge almost in line with the posterior border of the canine alveolus on the opposite side. The crown measures 25 mm. in long diameter on the alveolar border. P2 is reoresented by an empty alveolus 26 mm. back of p1. P3 is also lacking, and there is only a short space between it and p2, with the measurement of

[4a] Loc. cit., p. 192.

[5] Loc. cit., Pl. XVII.

which the supporting framework of the mounted skeleton now interferes. $P\underline{4}$ has its outer and back sides square, the inner rounded and the front deeply indented. On the anterior outer corner a prominence rises from the cingulum and the latter is present front and rear. Molars one and two are quadrangular, but too worn to show the crown patterns. Heavy cingula are present front and rear. In $m\underline{3}$ the crown narrows in width posteriorly, the outer wall of the tooth converges inward, and there is a small posterior cingulum.

In the lower series incisors and canines are represented by empty alveoli, as is also $p\overline{1}$, which, as indicated above, may have been either double-rooted or with a single grooved root. It is 14 mm. back of the canine and 16 mm. from the base of $p\overline{2}$. The latter is a double-rooted tooth without cutting edges in its present worn condition. The back of the crown is broken, so I can not determine whether it is of uniform width throughout. $P\overline{3}$ is long anteroposteriorly (52 mm. on alveolar border) in proportion to its width (20 mm.). The worn crown is convex on both sides and there are no cutting edges. There is a slight basal tubercle in front and a long sloping shelf behind, the worn area extending down over the posterior root below the enamel. The remaining teeth are in close series. $P\overline{4}$ is heavier and thicker than the preceding and wider in front than behind. The sides are plane and there are no cutting edges on the worn crown which measures 39 by 22 mm. The molars are well worn, but retain traces of cingula front and rear. The anterior cusps seemingly were higher than the posterior. $M\overline{3}$ has a prominent hypoconulid and the tooth crown is a little wider anteriorly than posteriorly. The other molars are of uniform transverse width.

II. From the Oreodon Beds.

Archæotherium wanlessi sp. nov.

Type No. 12522, Princeton University Geological Museum, collecting locality 1015A2a, a splendid uncrushed skull with attached lower jaw and the first to fourth cervical vertebræ (Figs. 5, 6, 21) found by Mr. H. R. Wanless of the 1920 South Dakota Expedition on the 14th of last July in a large rusty nodule weathered out of the "turtle-oreodon layer," lower Oreodon beds, probably in Sec. 5, T. 4 S., R. 13 E., Black Hills meridian, near the headwaters of one of the most easterly branches of Indian Creek, west of Hart Mountain, in Pennington County.

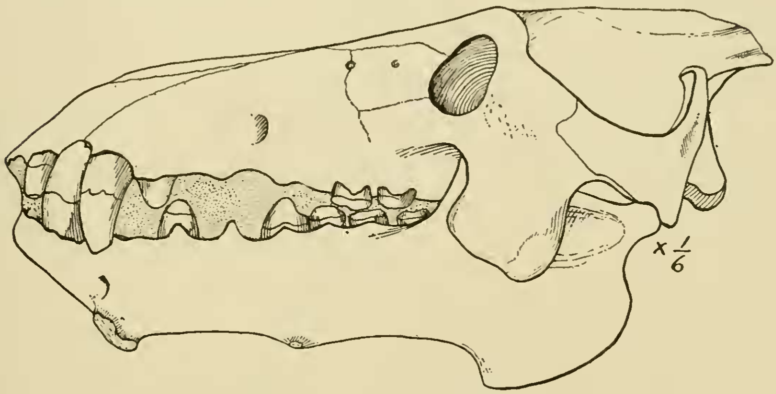

FIG. 5. *Archæotherium wanlessi* sp. nov. Holotype, No. 12522. Left side of the skull and lower jaw, one sixth natural size. Drawn from photograph and the specimen.

This new form which it is proposed to name after its discoverer, Mr. Wanless, is well differentiated from all of the larger White River entelodonts by the following characters, believed to be specific:

1. Marked peculiarities of the dependent malar processes. These are short, wide and thin, directed outward, downward and forward, and vastly shorter than in either *A. crassum* or *A. marshi*, which approach No. 12522 most closely in size. The antero-distal margin is 4–6 mm. thick, is slightly everted and is almost at right angles to the distal border which gradually thickens backward, due to a broad swelling whose center is about 30 mm. above the distal end of the process, where a maximum thickness of 19 mm. is attained. From here it thins out in all directions, but less rapidly so proximally. At its greatest antero-posterior expansion the process is 80 mm. wide and but 10 mm. less at its narrowest part. Its front margin is concave and well back of a line drawn through the posterior border of the orbit. From the upper edge of the temporal bar the outer face of the malar process is slightly sigmoid in longi-

tudinal section, concave proximally and convex distally. Transversely, it is convex at the narrowest part of the process and sigmoid toward the distal end, concave in front and convex behind.

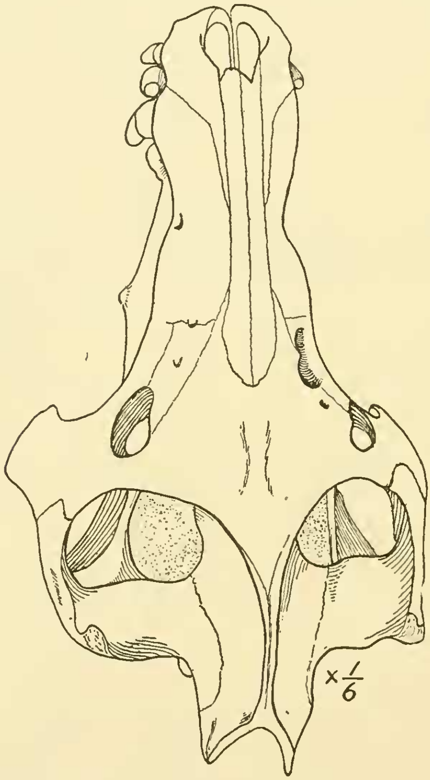

Fig. 6. *Archæotherium wanlessi* sp. nov. Holotype, No. 12522. Top view of the skull, one sixth natural size. Drawn from photograph and the specimen.

2. The structure of the zygomatic arch, used by Troxell as a specific variant. At its narrowest part the arch is but 41 mm. wide and the jugal process is slender, reaching the front margin of the glenoid fossa, but not taking part therein.

3. The character of the first lower premolar, which is said to be small and single-rooted in *A. marshi* and large and double-rooted in *A. crassum*. In *A. wanlessi* it has been lost on both sides and the excavation of the alveolus fails to reveal any trace of a cross septum,

suggesting that this tooth was not only single-rooted, but fairly large, the alveolus measuring 20 mm. antero-posteriorly. P$\overline{2}$ is a good-sized tooth (see table of measurements), separated from p$\overline{1}$ by an 18 mm. interval and from p$\overline{3}$ by a space of 8 mm.

4. The size and shape of the mental processes. These are rather small for such a large skull. The anterior process has a convex rugose surface, roughly elliptical to oval in outline, 40 mm. long by 23 wide, separated from the body of the ramus by a narrower neck 14 mm. wide in front, but thinning out to an edge behind and curving downward and outward. The posterior process is a low conical outgrowth, broad at the base, with blunt tip, and curving downward, outward and finally upward.

Measurements.

	Type of *A. wanlessi* No. 12522.	Type of *A. scotti* No. 10885.
Skull length, condyles to incisor border	562 mm.	672
Width across muzzle at alveolus of p$\underline{2}$	87	
Width of rami of lower jaws back of anterior mental tubercles	69	66
Anterior mental tubercles, lateral extent	92.5	157+
Posterior mental tubercles, lateral extent	163.5	227
Length of malar process below orbit	152.5	260
Width of process at narrowest point	70	88
Greatest width distally	80	115
Length of anterior process of temporal from glenoid cavity	82	
Length of symphysis	125	173
Depth of jaw below p$\overline{1}$	73	81
Depth of jaw below m$\overline{3}$	85	116
Upper premolar length	144	176
Lower premolar length	151	192
Lower molar length	91.5	107
Diameter, upper canine at base of enamel, antero-posteriorly	29	
Diameter, lower canine at base of enamel, antero-posteriorly	28	
Diameter p$\underline{1}$, antero-posteriorly	24	25
Diameter p$\underline{4}$, antero-posteriorly	24	30
Diameter m$\underline{1}$, antero-posteriorly	32	31.5
Diameter p$\overline{1}$, antero-posteriorly, alveolus only	20	28
Diameter p$\overline{2}$, antero-posteriorly	28.5	36±
Diameter p$\overline{3}$, antero-posteriorly	39.5	52
Diameter p$\overline{4}$, antero-posteriorly	34.5	39
Diameter m$\overline{1}$, antero-posteriorly	30	32.5
Diameter m$\overline{2}$, antero-posteriorly	33	35
Diameter m$\overline{3}$, antero-posteriorly	28	39

In preparation the skull and jaws have not been separated from their position in the matrix, so that the triturating surfaces of the teeth have not been exposed. The specimen shows interesting pathological structures in the shape of battle scars which will be discussed in a subsequent paragraph on the habits of entelodonts.

Archæotherium mortoni Leidy.

Five skulls of small entelodonts secured by the Princeton 1920 Expedition from the "turtle-oreodon layer" of the lower Oreodon beds in the drainage basins of Indian and Bear Creeks in Pennington County, South Dakota, agree so closely with Mr. Troxell's *A. clavus clavus* that, with his description before me, I can not separate our material from his. Another specimen, No. 11009, from the lower Oreodon beds in Corral Draw, collected by Mr. H. F. Wells in 1894, shows remarkably close agreement with *A. clavus darbyi* Troxell, the few differences between them not being of specific rank in my opinion. None of this material, however, have I been able to separate from *A. mortoni*. Although the type[6] of this species is a fragment of the left side of the face, with p*3* and p*4* in place, more complete skulls, originally in the collection of Dr. Owen, were later referred by Dr. Leidy himself to *A. mortoni* and beautifully figured,[7] constituting "heautotypes"[8] of the first order of importance. These specimens lack both dependent and posterior jugal processes, but otherwise agree closely with the Princeton material, allowing a certain amount of variation in size for difference in age, sex and individuals. Whatever be the ultimate status of Mr. Troxell's species, I am disposed to refer all of our small entelodonts from the Big Badlands to Leidy's *A. mortoni*.

Mr. Troxell's figured specimen of *A. clavus clavus* lacks the tip of the cheek flange, and it is also indicated as missing in the specimen figured by Peterson[9] and referred to *A. mortoni*. As this is complete in two of our Princeton skulls, I have illustrated it in the accompanying figures (Figs. 7, 8).

[6] Figured by Dr. Leidy in "Ancient Fauna of Nebraska," Pl. IX., Fig. 3.

[7] "Ancient Fauna of Nebraska," Pls. VIII., IX.

[8] Schuchert and Buckman, *Science*, n. s., Vol. 21, No. 545, p. 900, 1905.

[9] "A Revision of the Entelodontidae," *Memoirs Carnegie Museum*, Vol. IV., No. 3, Figs. 4–6, May, 1909.

In No. 12529, found last summer by Mr. Wanless in the clays of the "turtle-oreodon layer" of the lower Oreodon beds in the valley of Indian Creek, Pennington County, South Dakota, a young skull

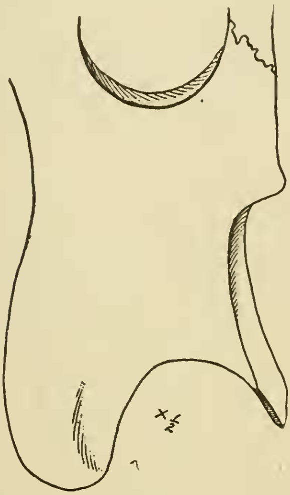

FIG. 7.

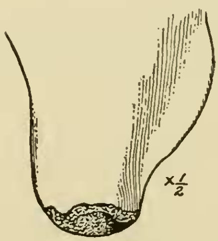

FIG. 8.

FIG. 7. *Archæotherium mortoni* Leidy. No. 12529. Portion of left jugal seen from the outer side showing both the dependent and the posterior processes, one half the natural size.

FIG. 8. *Archæotherium mortoni* Leidy. No. 11440. End of the dependent process of the right jugal showing concavity of anterior margin and thickening of distal end, one half the natural size.

with both milk and permanent premolars in place and the third molar just appearing, the process is slender and thin, 8 mm. in maximum thickness in the middle and about two millimeters thicker at the distal end. Transversely, it is 41 mm. at the widest part.

In the second specimen, No. 11440, from the lower Oreodon beds at the head of Sand Creek, Nebraska, collected by Mr. J. W. Gidley in 1896, the tip of the process on the right side seems to have been injured during life, for the anterior margin is concave distally and the process ends in an expanded area with a rugose flattened face measuring 15 mm. vertically by 27 transversely. No comparison can be made with the corresponding structure on the opposite side, as this has been broken off.

A. mortoni is represented by a larger number of specimens than any other entelodont in the Oreodon beds, especially in the zone of rusty caliche nodules in the upper part of the "red layer," from which came all the specimens of this species collected by the Princeton 1920 Expedition. Probably it will also be found to range down into the Titanotherium beds, but has not been identified with certainty in the Princeton collections from that horizon. Apparently it does not occur in the Protoceras beds.

Lower Jaws.

That there were at least two entelodonts of large size in the present area of the Big Badlands during the deposition of the "turtle-oreodon layer" of the lower Oreodon beds is shown by two lower jaws secured by the Princeton 1920 Expedition in the valley of Indian Creek in Pennington County. The larger of these, No. 12550, retains the mental processes and agrees so closely in size and configuration of the jaw with the type of *A. wanlessi* that I do not hesitate to refer it to that species. The incisors, tips of the canines and crowns of $p\bar{3}$ have been lost, but otherwise the dental series is complete (Fig. 9). The first premolar, measuring 21 mm. antero-

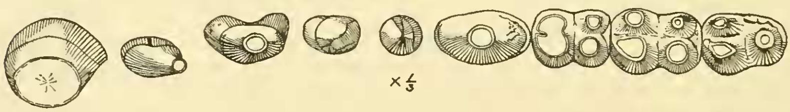

FIG. 9. *Archæotherium wanlessi* sp. nov. No. 12550. Crown view of the lower teeth of the left side, one third the natural size.

posteriorly, is double-rooted, but the roots are so close together that the empty alveolus would probably be indistinguishable from that of a single-rooted tooth. The anterior premolars are not as widely spaced as in the type (c–p1, 6.75 mm.; p1–$p\bar{2}$, 6.75 mm.; $p\bar{2}$–$p\bar{3}$, 5 mm.). $P\bar{2}$ is a stout tooth with slight anterior and posterior cingula and a blunt cutting edge front and rear. $P\bar{4}$ has a broad mammillated heel narrowing posteriorly and a strong anterior cingulum. The most peculiar feature of all is the presence of a single cusp, the hypoconid, on the talonid of $m\bar{3}$, internal to which there is a mammillated cingulum-like edge with hypoconulid and entoconid undifferentiated from the rest of this structure, except for a small swelling which perhaps corresponds to the entoconid. Unfortunately, these observations have to be based on a single tooth, for the corresponding molar on the right side has the crown badly shattered. There is less marked contrast in length and width between $m\bar{1}$ and $m\bar{2}$ than in the second lower jaw to be described, No. 12546, which, unfortunately, has lost the mental processes, but agrees closely with the dimensions given by Mr. Troxell for the paratype of Marsh's *Archæotherium crassum*, as may be gathered from the table of measurements given below. In this specimen (Fig. 10) $p\bar{1}$ is

FIG. 10. *Arthæotherium crassum?* (Marsh). No. 12546. Crown view of the lower teeth of the left side, one third the natural size.

definitely double-rooted, 10 mm. back of the canine and the same distance from $p\bar{2}$, which is 10–12 mm. from $p\bar{3}$, and the latter 4 mm. from $p\bar{4}$, which carries a broad mammillated heel, tapering in width posteriorly. The anterior molar seems proportionately smaller in comparison with the tooth back of it than in the other specimen, there is an external cingulum about the hypoconid in $m\bar{2}$, and $m\bar{3}$ has the normal heel development with two major cusps and a mammillated, cingulum-like hypoconulid. There is also close agreement in size with Leidy's fragmentary type of *A. robustum*,[10] where the hypoconulid in $m\bar{3}$ is a little stronger than in the Princeton specimen. The table of measurements below shows a close approximation to *crassum* and a rather wide departure from *mortoni*, and, in view of the extremely fragmentary character of the type of *robustum*, later referred by its author to *mortoni*, I am inclined to identify our specimen, provisionally, as *A. crassum*.

Still another form, perhaps to be referred to Leidy's *A. ingens*, is represented by a fragment of mandible in the Princeton collection, No. 10875, from the lower Oreodon beds in Corral Draw, South Dakota, where the single anterior mental process preserved is of the *ingens* type.

[10] "Ancient Fauna of Nebraska," Pl. X., Figs. 12, 13.

MEASUREMENTS.

	A. wanlessi.		*A. crassum.*		*A. mortoni.*
	Type, No. 12522.	No. 12550.	10036 Yale.	No. 12546.	No. 11440.
	mm.	mm.	mm.	mm.	mm.
Length of symphysis	125	125	122	107	97
Depth of jaw below $\bar{p1}$	73	68.5	57	63	55
" " " " $\bar{p2}$	72	72	60	69.5	51
" " " " $\bar{m2}$	85	80	72.3	79	51
" " " " m3	85	81.5	69	79.5	56.5
Narrowest part behind anterior mental tubercles, ventral	69	66	49	53	35
Narrowest part anterior to mental tubercles	73	72	63	68.5	46
Anterior mental tubercles, lateral extent	92.5	101 +	116	?	72
The same for posterior mental tubercles	163.5	192	143	?	103
Space occupied by lower pms. and ms	242.5	253	216	218	196
Lower premolar length	151	158	135	142	128.5
Lower molar length	91.5	98	76	77	70
$\bar{P4}$, anteroposterior diameter	34.5	37	29	32.5	25.5
$\bar{M2}$, transverse diameter	?	26	22	19	16.5
$\bar{M2}$, anteroposterior diameter	33	35	26	27	24

III. From the Protoceras Beds.

Scaptohyus altidens gen. et sp. nov.

Type No. 11161, Princeton University Geological Museum, front of skull, lower jaws, left cheek flange and minor fragments from the Protoceras beds in Corral Draw, South Dakota, collected by R. E. Zuver, cook of the 1893 Expedition.

This remarkable entelodont has figured several times in the literature because of the striking way in which it demonstrates the digging habits of the animal. I have long been aware that the specimen represented an undescribed form, and now propose it as the type of a new genus *Scaptohyus* ("digging pig") and species *altidens* in reference to the great height of the third lower premolar (Figs. 11–17). With Professor Scott's kind permission, I reproduce from "A History of Land Mammals in the Western Hemisphere," Macmillan Company, his Fig. 194, with certain corrections which I fear detract from the artistic quality of Mr. Horsfall's drawing, but express more accurately the structures present (Fig. 13). In reference to them, Professor Scott writes "the external, or third, upper incisor tooth has a deep, triangular notch worn in its posteroexternal face, and the lower canine has a well-defined groove worn on the posterior side at the base of the crown. . . . It is out

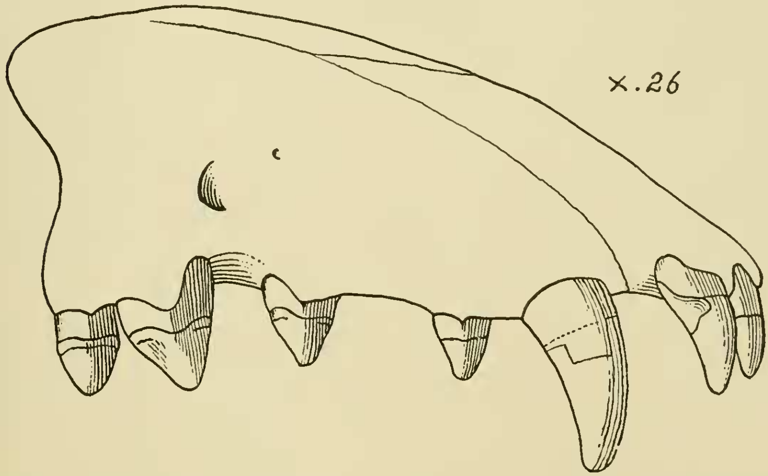

FIG. 11. *Scaptohyus altidens* gen. et sp. nov. Holotype, No. 11161. Front of skull from the right side, about 0.26 natural size. Drawn from photograph and the specimen.

of the question to suppose that these grooves and notches could have been produced by abrasion with other teeth, for no other teeth could reach the worn areas, and it is altogether probable that they

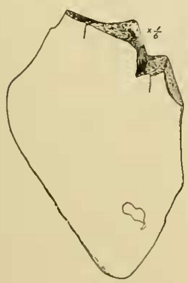

FIG. 12.

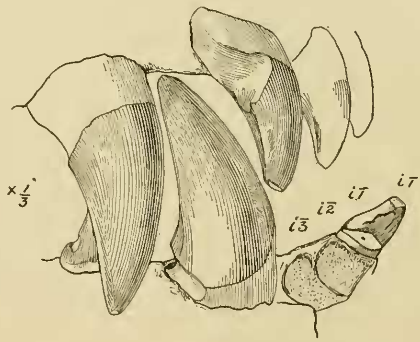

FIG. 13.

FIG. 12. *Scaptohyus altidens* gen. et sp. nov. Holotype, No. 11161. Fragment of the dependent process of the left jugal, one sixth natural size.

FIG. 13. *Scaptohyus altidens* gen. et sp. nov. Holotype, No. 11161. Upper and lower incisors and canines showing the grooves worn by root-digging, one third the natural size.

were made in digging up roots. The root, held firmly in the ground at both ends and looped over the teeth which pulled until it broke, and being covered with abrasive grit, would wear just such marks as the teeth actually display." I have modified the drawing of the worn area at the base of the upper canine and redrawn the lower incisors, of which but one, the left i$\overline{1}$, remains, a small tooth sloping forward, the point flanked on either side by subsidiary, mammillated cuspules. Broken stumps of the first right and third left incisors remain and these are worn down flush with the gum by the same root-digging which grooved the other teeth. I have endeavored to suggest this habit in the generic name proposed.

Striking differences in both dental and cranial characters separate *Scaptohyus* from the other large entelodonts of the Protoceras beds, with which it can not possibly be confused if adequate material for comparative purposes is available. The large upper incisors point vertically downward, unlike the Princeton specimen of *Megachœrus,* and, in shape, are hemi-cones, flattened internally, the third grooved on the outer side in the manner already described. A similar broad groove is found on the posterior inner surface of the upper canine at the base of the enamel.

P$\underline{1}$ is small, but double-rooted, measuring 34 mm. anteroposteriorly on the alveolar border by 16 transversely, and separated from the canine in front by a 19 mm. interval and from p$\underline{2}$ by a space 47–52 mm. long. The crown is convex on both sides, with finely rugose enamel, is thicker in front than behind, with acute edges front and rear, and curves slightly backward. There is a very slight cingulum both antero- and postero-internally.

P$\underline{2}$ is stouter and also double-rooted, 37 mm. anteroposteriorly on the alveolar border by 21 transversely, is convex on both sides, curves inward, with weak cingulum front and rear and a sharp cutting edge behind, but extending only half way down the crown in front. Enamel faintly rugose. Diastema of 32–43 mm. between this tooth and the next in series.

P$\underline{3}$ is a large simple cone without heel, 46½ mm. anteroposteriorly by 30 transversely. The crown has a moderate cingulum internally, broad cutting edge posteriorly and many vertical ridges and furrows running lengthwise, both front and rear. The enamel is rugose, the crown slightly incurved and the tooth almost in contact with $p\underline{4}$.

$P\underline{4}$ has two high cones, of which the deuterocone is slightly the higher, and measures 37 mm. anteroposteriorly (externally) by 36 transversely. The crown is much wider externally because of the strong indentation anteriorly as in *Archæotherium*. The outer and back sides are square, the inner side rounded and the front broadly notched. The cingulum is very strong posteriorly with minor mammillations. Elsewhere it is less strong and is continuous about the crown except for a small space on the inner side.

The part of the skull retaining these teeth (Fig. 11) has been laterally crushed and drawn out to some extent, so that corresponding diastemata on opposite sides are not always of the same length. The infraorbital foramen is above and in line with the front edge of *p3*.

In the lower jaw the incisors have already been described and illustrated in discussing the root-digging habits of the animal. The canines are strongly curved outward and backward and each has a deep groove at the base of the enamel posteriorly, over which the thin edge of the alveolus has partly grown.

$P\overline{1}$ is small, double-rooted and laterally compressed, with sharp cutting edges front and rear and a backward and inwardly curved crown. It is 7 mm. back of the canine and in line with it, and out of line with all the other teeth. It measures, on the alveolar border, 31.5 by 19 mm., narrowing posteriorly. There is a 25 mm. diastema back of it. On the right side its posterior edge is notched by root digging (Fig. 13).

$P\overline{2}$ is rather small and double-rooted, 39 mm. anteroposteriorly on the alveolar border by 21 transversely, with a very high, sharp-pointed crown curving slightly backward and inward and with a sharp edge posteriorly. Enamel finely rugose. Diastema back of this tooth 20–23 mm. long.

$P\overline{3}$ is a great tooth 54½ mm. anteroposteriorly on the alveolar border by 28 at the widest part of the crown and rises 84 mm. above the alveolar border in front. It is a single cone with no heel, somewhat recurved, with a strong posterior cutting edge and moderate anterior and posterior cingula, extending round on the outer face of the tooth. The enamel is rugose and there are numerous minor vertical ridges and grooves above the base of the tooth, both externally and internally.

P$\bar{4}$ is about as high as p$\bar{2}$, 46½ mm. anteroposteriorly by 27 wide, with a prominent heel supporting minor cuspules and moderate cingulum continuous except for a gap internally. The enamel is rugose and there is a single posterior mammillated cutting edge at the outer angle of the crown.

The molar crowns, although worn externally, show that the cusps of the trigonids are much higher than the talonids. The enamel is rugose where not smoothed by wear. M$\bar{1}$ is of equal width, front and rear; the other molars are wider in front. All have medium-sized hypoconulids, rugose masses not well differentiated from the posterior cingulum above which they rise. In all, the entoconid is smaller than the hypoconid. Anterior and posterior cingula are present, with strong remnants of external cingula at the ends of the transverse valleys. In m$\bar{3}$ the tip of the anterointernal cusp is bifid. The other molars are too worn to show it, if present. The dimensions of the molars are as follows:

M$\bar{1}$, anteroposteriorly	40.5 mm.
M$\bar{1}$, transversely	27.5
M$\bar{2}$, anteroposteriorly	43.5
M$\bar{2}$, transversely (anteriorly)	36
M$\bar{3}$, anteroposteriorly	47
M$\bar{3}$, transversely (anteriorly)	36

The lower jaw (Figs. 14, 15) has been shortened by crushing, which has jammed together the molars and posterior premolars and bent outward the posterior halves of the rami. The chin is at right angles to the lower margin of the rami, is wide above, narrow below, almost flat in front, and the anterior mental processes which are small and extend but little below its lower border merely accentuate slightly the corners of the great quadrangular chin (Fig. 14). The symphyseal region is very wide (190 mm. across the swollen bases of the canines, with a length of 144 mm. from the incisor border to the junction of the rami), so wide that the canine and p$\bar{1}$ are well outside the line of the other teeth (Fig. 17). The posterior mental processes, on the other hand, are long, directed forward and of uniform width.

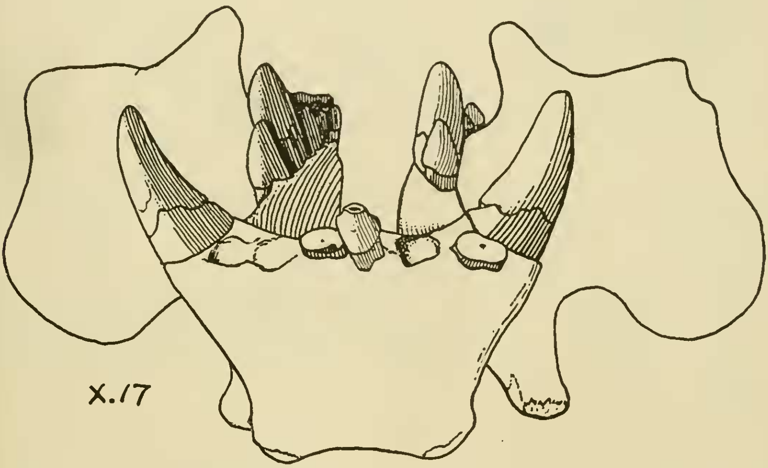

FIG. 14. *Scaptohyus altidens* gen. et sp. nov. Holotype, No. 11161. Lower jaws seen from in front, about 0.17 natural size. Drawn from photograph and the specimen.

A fragment of the distal end of the left cheek flange shown in Fig. 12 has the thin front margin concave to the point of greatest expansion, beyond which it extends backward in a straight line and rapidly thickens to the distal end, where the maximum thickness is 36 mm. What little remains of the thin posterior margin is also

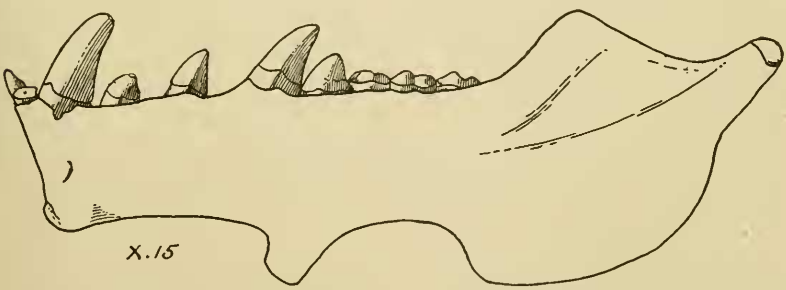

FIG. 15. *Scaptohyus altidens* gen. et sp. nov. Holotype, No. 11161. Side view of left half of lower jaw, about 0.15 natural size. Drawn from photograph and the specimen.

concave. Transversely, the process is convex externally in both directions, and slightly concave longitudinally and transversely on

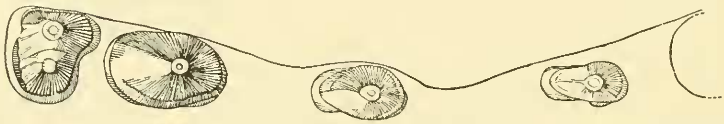

FIG. 16. *Scaptohyus altidens* gen. et sp. nov. Holotype, No. 11161. Crown view of the upper premolars of the right side, one third the natural size.

the inner surface. It is 139 mm. wide across the maximum lateral expansion.

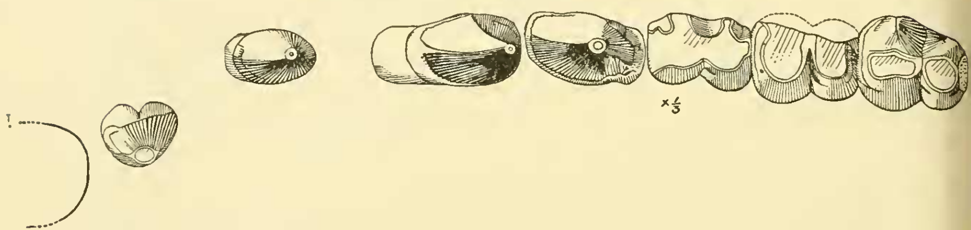

FIG. 17. *Scaptohyus altidens* gen. et sp. nov. Holotype, No. 11161. Crown view of the left lower premolars and molars, one third the natural size.

Megachœrus zygomaticus Troxell.

No lower jaw is associated with the type skull of this form (No. 10008, Yale Palæontological Museum). Fortunately, a somewhat better preserved skull in the Princeton collection, No. 11156 (Figs. 18, 19), with a card-index record in Mr. Hatcher's handwriting stating that it was found in the Protoceras beds south of White River by the Princeton Expedition of 1894, has the right half of the lower jaw preserved, bringing out additional characters for the separation of *Megachœrus* from its contemporary *Pelonax*.

Close checking of the Princeton specimen with Mr. Troxell's description[11] fails to show differences which can be regarded as of more than individual or, perhaps, sexual value. The most striking of these is the thickening of the distal end of the dependent malar process to 30 mm., the thickening lengthwise of the central part of the flange to 27 mm. by the development of a longitudinal convexity

[11] Loc. cit., p. 433 and following.

on the under side, and its greater thinness at the point where the temporal process is given off (18 mm. in comparison with Troxell's figure of 30 mm.). There is the same peculiar wing-like shape and

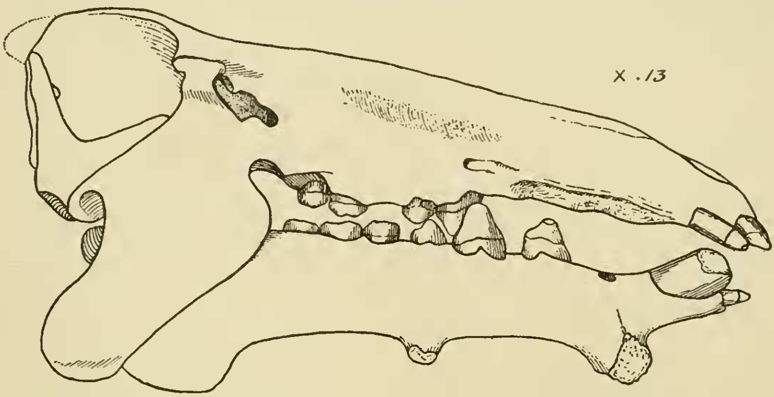

FIG. 18. *Megachœrus zygomaticus* Troxell. No. 11156. Side view of skull and jaws, about thirteen one-hundredths natural size. The orbits are deformed by vertical crushing. Drawn from photograph and the specimen.

backward sweep to these great structures as in the type of the genus, correspondence in their width, and in the shape and relation of the posterior jugal process to the glenoid cavity, into the formation of which it enters. In the shape of the anterior process of the temporal and the shape and position of the infraorbital foramen there is also close agreement. In the Princeton specimen the frontals have a shallow posterior depression lodging two small foramina which the engraver has failed to show (Fig. 19).

The characters of the upper dentition agree almost completely. In our specimen $p\underline{1}$ was small and directed forward, but whether single- or double-rooted can not be ascertained from the empty alveolus. An extensive injury, sustained during life, obliterated all trace of teeth and their alveoli on the right side from canine to $p\underline{2}$, inclusive. On the left side $p\underline{2}$ is missing, but was preceded by a diastema of 52 mm. and followed by a space of 11 mm. or more. P3 is pyramidal, but not noticeably "angular," rounded on the outer side, wider posteriorly than in front and broadly concave at the base internally. The ridging and pitting of the crown mentioned by

Troxell have been largely obliterated by wear, but traces remain. If there ever was a heel, it has been lost by abrasion. The anterior notch in p4, absence of which was noted by Troxell, is but slightly indicated, and the tooth is a little smaller in anteroposterior diameter than in his specimen (28.5 mm. anteropost. by 34.5 trans. as compared

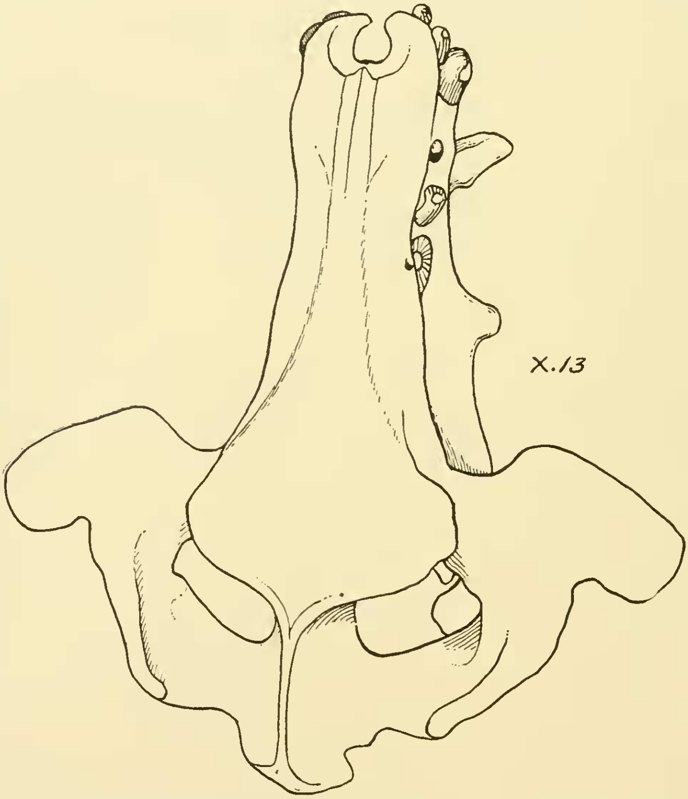

FIG. 19. *Megachœrus zygomaticus* Troxell. No. 11156. Skull and lower jaws as seen from above, about thirteen one-hundredths natural size. Drawn from photograph and the specimen.

with 31 by 34). M2 is slightly different in dimensions (42 ant.-post. by 47 mm. trans. anteriorly as compared with 40 by 42.5 in the Yale specimen). In all other respects, so far as I can judge, there is the closest agreement, and I do not hesitate to identify our specimen as *Megachœrus zygomaticus,* perhaps an old male as inferred from the thicker cheek flanges and signs of injury.

MEASUREMENTS.

	Type, No. 10008 Y. P. M.	No. 1156. Princeton
Skull length, condyles to incisor border	760 mm. (estimated)	770 mm.
Width across muzzle at alveolus of p2	96	100
Length of malar process below orbit		339.5
Width of process at narrowest point, distal to greatest expansion		102
Greatest width of process		146
Length of anterior process of temporal from glenoid cavity		135
Length of symphysis		150±
Depth of rami at p2		86
Depth of rami at m2		102
Upper premolar length	186	194
Upper molar length	112	112
Lower premolar length		218
Lower molar length		124
Diameter, p3, anteroposterior		39
Diameter, p4, anteroposterior	31	28.5
Diameter, p4, transverse	34	34.5
Diameter, m1, anteroposterior		33
Diameter, m1, transverse		44
Diameter, m2, anteroposterior	40	42
Diameter, m2, transverse anteriorly	42.5	47
Diameter, m3, anteroposterior		36
Diameter, m3, transverse at widest part		41
Diameter, p2, anteroposterior		47
Diameter, p3, anteroposterior		52.5
Diameter, p4, anteroposterior		41
Diameter, p4, transverse		24
Diameter, m1, anteroposterior		36
Diameter, m1, transverse		27
Diameter, m2, anteroposterior		41.5
Diameter, m2, transverse		34
Diameter, m3, anteroposterior		42

The lower jaw lacks condyle and angle, which have been reconstructed in plaster, and the latter may be too small. While the first lower premolar is single-rooted and close to the canine as in *Pelonax,* the second premolar is a large double-rooted tooth, supported on stout high roots and almost as long anteroposteriorly, when measured on the alveolar border, as p3 (p2, 47 mm.; p3, 52.5 mm.). Furthermore, it is widely spaced front and rear (27 mm. in front, 21.5 behind), quite unlike *Pelonax.* Size further distinguishes this tooth from *Pelonax,* where it is either small and single-rooted (*P. ramosus*) or small and double-rooted (*P. potens*). $P\bar{3}$ is a very large tooth, imperfect at tip and posterointernally, and lacks a heel, so far as can be judged in its present worn condition. $P\bar{4}$ seems small by comparison with the tooth in front. It has no anterior cuspule (surface worn), but a good-sized heel. The molars are too worn and too much reconstructed to warrant description. The gap between $p\bar{4}$ and the first molar is accidental, due to distortion and stretching of the specimen. The canines are worn to stumps and the few incisors remaining point straight forward, the chin being exceedingly procumbent, perhaps accentuated by crushing.

The anterior mental process is very long, projecting outward and forward, with roughened distal end, and is attached to the ramus by a triangular neck with concave faces, the anteroexternal one concave in all directions, the posteroexternal larger and more broadly concave, and the inferior one concave proximo-distally and undulatory transversely. The posterior process is strong, expanded distally to a bulbous tip which is no wider anteroposteriorly than the neck supporting it, and directed downward and outward.

Additional characters are the forward slope of the upper incisors and the extremely long and slender face.

Other Forms.

Remains of entelodonts of a smaller size than those just described occur in the Protoceras beds, as shown by specimens in the Princeton collection, but most of the material is too incomplete to be even generically determinable with certainty. No. 11124, the front of a skull with complete premolar and molar dentition, collected by Mr. Hatcher in 1894 from the Protoceras beds on Cottonwood Creek in what is now Washington County, South Dakota, differs from all other entelodonts except *Megachœrus zygomaticus* and *Entelodon magnum* in almost completely lacking the notch in the

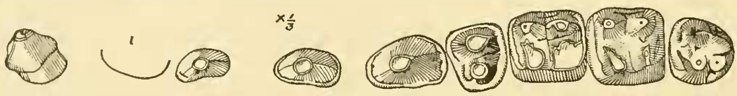

Fig. 20. Undetermined entelodont from the Protoceras Beds, No. 11124, showing upper dentition of the left side, one third the natural size. $P\underline{4}$ lacks the notched anterior border.

anterior border of p4 (Fig. 20). It is smaller than *Entelodon magnum*, from which it also differs in having the posterior part of p3 less broad and the inner half of p4 narrower anteroposteriorly, so that the anterior border curves backward and inward. On the opposite side from that figured this border is slightly more concave than I have drawn it, but on neither side is there anything like the deep notch seen in *Archæotherium* and *Scaptohyus*. In the oblique position of p1 behind the canine and the spacing of the anterior premolars, the specimen resembles *Archæotherium*, but in the structure of p4 it represents a distinct departure from all the American genera. As skull characters are not available, I refrain from giving it a name. It is a shorter-faced form than *Megachærus* and has the lateral incisor erect instead of procumbent. Still another, but very much larger, animal, apparently distinct from the forms just described from the Protoceras beds, is represented by various fragments.

Habits of Entelodons.

Apart from the digging proclivities of *Scaptohyus*, already described, one of the most clearly indicated habits of the entelodonts

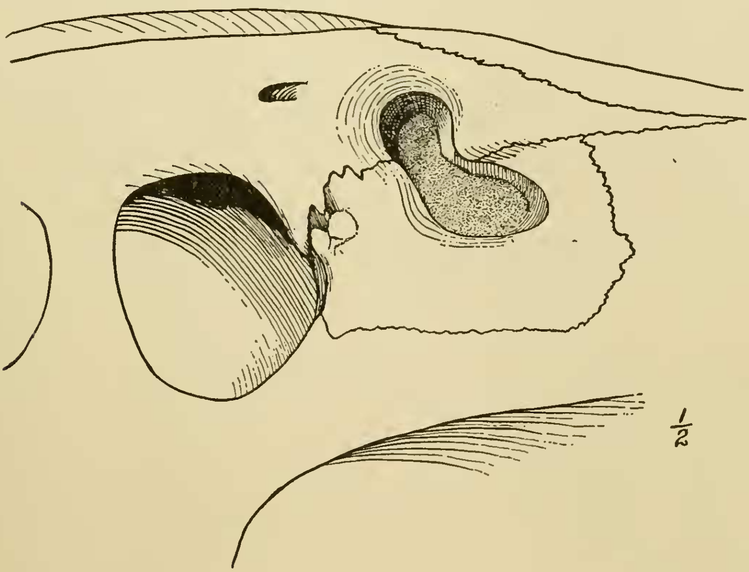

FIG. 21. *Archæotherium wanlessi* sp. nov. Holotype, No. 12522. Right side of the ant-orbital tract showing injury, one half the natural size.

is their extreme pugnacity. In preparing the skull of *Archæotherium wanlessi,* I was surprised to find a large antorbital vacuity on the right side, shaped much like an obliquely inclined figure eight (Fig. 21), completely perforating the surface of the lachrymal and adjacent anterior tongue of the frontal. A slight indentation occurs also on the frontal above the orbit, and on the opposite side of the skull are two shallow depressions toward the upper edge of the lachrymal, one on the maxillo-lachrymal suture and the other farther back (Figs. 5, 6). All of these seem to be correctly interpretable as battle scars and to indicate that this individual was gripped in front of the eyes by the powerful jaws of an opponent.

Fig. 22. *Archæotherium scotti* sp. nov. Holotype, No. 10885. Left jugal process showing injury to anterior margin, one half the natural size.

In the specimen of *Archæotherium scotti,* Princeton Geological Museum 10885, not only is there a fractured rib which never healed, leaving a large callus on each of the broken ends, with an irregular suture separating them, but the left cheek flange has had the front margin bitten off (Fig. 22), showing clearly by the scalloped outline where the canines and adjacent incisors penetrated (compare with Fig. 1).

Function of the Dependent Malar Processes.

Incidentally this has a bearing on the function of the jugal process. Mr. Troxell thinks that it "in all probability gave origin to the masseter muscle which generally arises from the jugal and is inserted broadly on the wide angle of the ramus," and that "from the tip of the process the fibers of the muscle might have given the forward, the backward and even a sideward movement of the mandible. . . ."[12] It seems to me equally probable that the process in question extended over the masseter without giving origin to it, and projected sufficiently beyond the outer surface of the cheek to afford a handy grip to an antagonist. In *A. scotti*, No. 10885, both outward curvature and relative length of the cheek process are somewhat increased by the distortion of the specimen.

Résumé.

Restricting the survey to the Big Badlands of South Dakota and combining data from the Yale and Princeton collections, we have the following range of forms in time:

I. Titanotherium beds.

Archæotherium scotti sp. nov.
Archæotherium marshi Troxell.[13]

II. Oreodon beds.

Archæotherium wanlessi sp. nov.
Archæotherium mortoni Leidy.
Archæotherium ingens Leidy.
Archæotherium crassum? (Marsh).

III. Protoceras beds.

Megachœrus zygomaticus Troxell.
Megachœrus latidens Troxell.[14]

[12] Loc. cit., p. 255.

[13] North bank of Cheyenne River between French Creek and Battle Creek, South Dakota, associated with *Brontotherium* and *Hyracodon*. Troxell, loc. cit., p. 386, footnote.

[14] Probably Upper Oligocene, near Cheyenne River, South Dakota. Troxell, loc. cit., p. 437.

Pelonax bathrodon (Marsh) Peterson.[15]
Scaptohyus altidens gen. et sp. nov.
Unnamed form a.
Unnamed form b.

It will be noticed at once that *Archæotherium* is not listed from the Protoceras beds. Whether it is really absent or merely lacking from the collections so far examined is uncertain, nor is it yet possible to say to what extent the species listed from the Titanotherium and Oreodon beds respectively are confined to these levels. *A. wanlessi, A. mortoni* and *A. crassum*? are found in the zone of rusty nodules in the upper part of the "turtle-oreodon layer" of the lower Oreodon beds, and were certainly contemporary.

The origin of the group as a whole is uncertain. The Eocene achænodonts, as Professor Osborn points out,[16] are too specialized in the teeth to be regarded as directly ancestral. The European genus *Entelodon* and the American *Archæotherium* both appear in the lower Oligocene, and, as Professor Osborn suggests, may have sprung alike from an unknown northern or Holarctic form. A significant fact bearing on this general subject is the sudden appearance in the Protoceras beds of several types of entelodonts, both large and small, in which the shape of the fourth upper premolar agrees more closely with the character of that tooth in the European genus than in *Archæotherium*. Perhaps this is to be explained as a new faunal invasion. *Megachærus zygomaticus,* the small form which I have not named, and a still larger individual represented in the Princeton collection by some teeth and other fragments, all show this character. On the other hand, *Megachærus latidens* Troxell and *Scaptohyus altidens* gen. et sp. nov. have the anterior border of the tooth in question indented, as in *Archæotherium*. Further discussion of the affinities of entelodonts in general and the forms from the Protoceras beds in particular may be postponed until the collection of the American Museum of Natural History has been studied. This contains excellent material of one or more undescribed large

[15] Protoceras sandstones? Big Badlands of South Dakota, Peterson, loc. cit., pp. 57, 58.

[16] "The Age of Mammals," pp. 217, 218.

forms from the Protoceras beds, perhaps the same as some of the fragmentary specimens in the Princeton collection already referred to. With the kind permission of Professor Osborn and Dr. Matthew, I hope to pursue these studies farther, on the collections in their charge.

The facts presented regarding habits amplify Professor Scott's published observations and have an important bearing on the supposed function of the dependent process of the jugal which projected far enough beyond the cheek to be grasped and badly injured by the teeth of an adversary.